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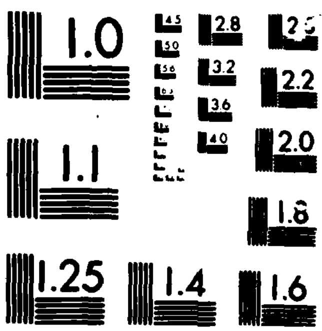

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AFOSR-TR- 86-0239

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COHERENT SCATTERING OF LIGHT BY CRYSTALS

Final Report

to

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

J. Weber

University of Maryland, College Park, Maryland

and

University of California, Irvine, California

1985

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UNIVERSITY OF MARYLAND
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Collective absorption of photons by the spin system is observed, if the spins are polarized by a magnetic field, and appropriate polarized light employed.

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Collective absorption of photons by the spin system is observed, if the spins are polarized by a magnetic field, and appropriate polarized light employed.

INTRODUCTION

For the past several years we have been studying coherent scattering of red light from a Helium Neon Laser, by sapphire and lithium fluoride crystals. The theory has been presented in earlier proposals, and reports. This theory predicts that nearly perfect crystals with nuclei having magnetic moments, will absorb light by a collective spin state change. Thus many nuclei change their spin state in a magnetic field, absorbing a single red photon. ---> 147?

Experiments

Figure 1 shows the experimental arrangement. Light from the Laser interacts with a crystal in a magnetic field at low temperatures. A long period, about 36 hours, is required for the nuclear spins to achieve thermal equilibrium with the lattice. It is therefore expected that the crystal will be transparent initially and become opaque on a time scale of the hours required for the spin polarization to approach equilibrium values.

Experiments During the Current Grant

Theory predicts that the light must be polarized with magnetic field vector parallel to the applied field which polarizes the nuclei. Early experiments employed an unpolarized laser together with a polarizer, and these gave consistent results for an extended period.

During the present grant period this unpolarized laser was again employed. Data were erratic and not reproducible. A series of experiments revealed that an "unpolarized" laser does age and its output may be polarized with an uncertain variable direction.

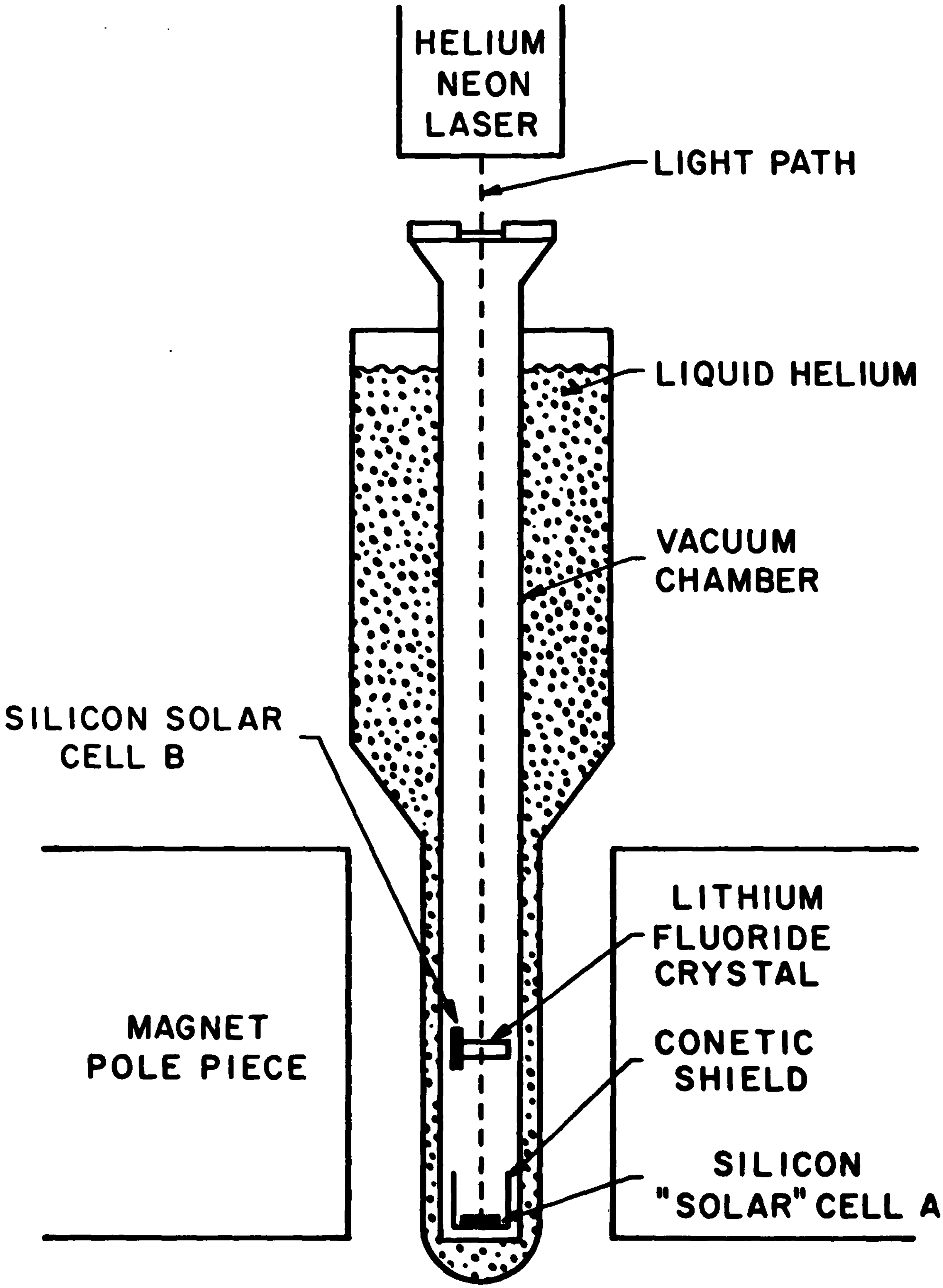
HELIUM
NEON
LASER
LIGHT PATH
LIQUID HELIUM
VACUUM
CHAMBER
SILICON SOLAR
CELL B
LITHIUM
FLUORIDE
CRYSTAL
MAGNET
POLE PIECE
CONETIC
SHIELD
SILICON
"SOLAR" CELL A

FIGURE 1

The laser was then replaced by a polarized one milliwatt laser. Two neutral density attenuator filters and a diffuser were employed to illuminate the entire crystal. The Dewar was filled with liquid helium and an 8000 Gauss magnetic field applied. An extended series of experiments was carried out. Results were affected by the change in level of liquid helium in the Dewar. Addition of liquid nitrogen and refilling with liquid helium enormously increase the phonon level and affect the spin lattice relaxation time. The crystal does become opaque to red light on the time scale of the spin lattice relaxation time.

Conclusions

As a result of the extended series of measurements, it may be concluded that the collective absorption of red light by polarized nuclear spins is being observed. The selection rule derived in earlier reports--magnetic field vector of light parallel to applied magnetic field for greatest absorption--appears to be valid.

Starting with a one milliwatt polarized laser, the light is collimated, attenuated by neutral density filters to avoid heating the crystal, and permitted to interact with the crystal at low temperatures.

When the magnetic field is first applied immediately after cooldown, the light power transmitted to the photometer is 10^{-4} ergs per second. This drops by more than a factor ten, to a value too small to observe, on a time scale of approximately 24 hours. This confirms the earlier observations with an "unpolarized" laser.

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